

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

CANADA

THE PATENT OFFICE

PATENT No. 532,893 ISSUED NOV. 6, 1956

Roofs for Storage Tanks or Similar Structures

Robert H. Foster, London, England, and James McLean, Motherwell, Lanarkshire, Scotland, the latter assignor to The Motherwell Bridge and Engineering Company Limited, Motherwell, Lanarkshire, Scotland

Application December 29, 1952, Serial No. 640,855

In Great Britain December 28, 1951

8 Claims

1

This invention relates to the roofs of tanks for the storage of liquids, or of other similar structures. The invention provides a form of roof construction particularly suitable for application to structures having a diameter of about 50 feet or less, which permits considerable economies in the amount of steel and workmanship employed, as compared with previously known forms of roof.

The invention includes broadly a conical roof for a circular structure such as a liquid storage tank, which comprises a peripheral curb, a plurality of radially disposed sheet metal panels, together constituting the conical roof surface, which abut at their outer ends against the curb, and a centrally disposed crown member to which all the panels are secured at their inner ends, the panels, some at least of which are provided with stiffening flanges, being otherwise unsupported so that they act as half arches with continuity through the crown member.

Other features of the invention will sufficiently appear from the appended claims, when read in the light of the following description of the particular form of roof constructed in accordance with the invention, and of some of the many possible modifications of this construction, which are illustrated in the accompanying drawings. In these drawings:

Figure 1 is a plan view of part of the completed structure;

Figures 2 and 3 are fragmentary plan views showing parts of the structure on a larger scale;

Figures 4 and 5 are fragmentary vertical radial sections through the structure, taken respectively on the lines IV-IV and V-V of Figures 1, 2 and 3;

Figure 6 is a circumferential section taken on the line VI-VI of Figure 1, and

Figures 7, 8 and 9 are views, corresponding to Figure 6, of modified constructions.

The roof illustrated in Figures 1 to 8 is intended for use upon an oil storage tank having a vertical cylindrical side wall, 35 feet in diameter. The roof is of conical shape, having a slope of 1 unit vertically in 6 units horizontally. It comprises 30 radially disposed panels formed from $\frac{3}{16}$ " thick plate, which extend from the top of the side wall 10 of the tank to a central crown member 11. One of these panels 12, which is the first to be placed in position, is flanged along both of its radial edges; the 28 similar panels 13, which are positioned next,

2

are flanged along one radial edge only and the final closing panel 14 is unflanged. In each case, the flange comprises a downwardly projecting portion 15, which is 3 inches deep, and a horizontal inturned portion or return flange 16 which is 2 inches wide. At the junction between each pair of adjacent panels, an unflanged edge of one panel overlaps a flanged edge of the other panel by $1\frac{1}{2}$ inches, the unflanged edge being secured by a continuous weld to the upper surface of the adjacent underlying panel. Each panel acts as a half arch, supported at its outer end and continuous through the centre ring with the diametrically opposite half arch.

At the upper edge of the side wall 10 of the tank is a curb 17 formed from curved angle sections, measuring $3\frac{1}{2}$ inches by $2\frac{1}{2}$ inches by $\frac{3}{16}$ inch, site welded into a continuous ring. As best seen from Figure 4, the curb angle is secured with its shorter limb against the outer surface of the side wall 10 and with its longer limb extending horizontally outward from the upper edge of the wall, by continuous fillet welds at the top of the side sheeting and at the lower edge of the vertical limb of the curb. The outer end of each flange of the roof panels is cut away so that when the end surface of the flange is against the side wall the top portion of the panel overlaps the curb angle. The outer end of the return flange 16 rests on a bracket formed by a bent plate cleat 18, site welded to the vertical side wall 10, which takes the vertical reaction from the flanged part and distributes it gradually down the shell plating. A bolt 19 passes through registering holes in the return flange 16 and cleat 18.

At the inner end of each flange of the roof panels (see particularly Figure 5) a 3 inch square by $\frac{1}{4}$ inch thick pad plate 20 is welded on to the end surface of the flanged portion, the vertical flange 15 and return flange 16 being cut away so that the outer surface of plate 20 is vertical and flush with the end of the top portion of the panel. The central crown member 11 is in the form of a ring fabricated from steel plates and has an outside diameter of 3 feet, an internal diameter of 1 foot 10 inches and a depth of 4 inches. It is composed of two annular plates 21, 22 connected together by two vertical cylindrical plates 23, 24 the connection between the plates being made by welding. The inner ends of the flanged panels abut against

5 This invention relates to the roofs of tanks for the storage of liquids, or of other similar structures. The invention provides a form of roof construction particularly suitable for application to structures having a diameter of about 50 feet or less, which permits considerable economies in the amount of steel and workmanship employed, as compared with previously known forms of roof.

10 The invention includes broadly a conical roof for a circular structure such as a liquid storage tank, which comprises a peripheral curb, a plurality of radially disposed sheet metal panels, together constituting the conical roof surface, which abut at their outer ends against the curb, and a centrally disposed crown member to which all the panels are secured at their inner ends, the panels, some 15 at least of which are provided with stiffening flanges, being otherwise unsupported so that they act as half arches with continuity through the crown member.

20 Other features of the invention will sufficiently appear from the appended claims, when read in the light of the following description of the particular form of roof constructed in accordance with the invention, and of some of the many possible modifications of this construction, which 25 are illustrated in the accompanying drawings. In these drawings:

Figure 1 is a plan view of part of the completed structure;

Figures 2 and 3 are fragmentary plan views showing parts of the structure on a larger scale;

30 Figures 4 and 5 are fragmentary vertical radial sections through the structure, taken respectively on the lines IV - IV and V - V of Figures 1, 2 and 3;

Figure 6 is a circumferential section taken on the line VI - VI of Figure 1, and

Figures 7, 8 and 9 are views, corresponding to Figure 6, of modified constructions.

5 The roof illustrated in Figures 1 to 6 is intended for use upon an oil storage tank having a vertical cylindrical side wall, 35 feet in diameter. The roof is of conical shape, having a slope of 1 unit vertically in 6 units horizontally. It comprises 30 radially disposed 10 panels formed from 3/16" thick plate, which extend from the top of the side wall 10 of the tank to a central crown member 11. One of these panels 12, which is the first to be placed in position, is flanged along both of its radial edges; the 28 similar panels 13, which are positioned next, 15 are flanged along one radial edge only and the final closing panel 14 is unflanged. In each case, the flange comprises a downwardly projecting portion 15, which is 3 inches deep, and a horizontal inturned portion or return flange 16 which is 2 inches wide. At the junction between 20 each pair of adjacent panels, an unflanged edge of one panel overlaps a flanged edge of the other panel by 1 $\frac{1}{2}$ inch, the unflanged edge being secured by a continuous weld to the upper surface of the adjacent underlying panel. Each panel acts as a half arch, supported at its outer end and 25 continuous through the centre ring with the diametrically opposite half arch.

At the upper edge of the side wall 10 of the tank is a curb 17 formed from curved angle sections, measuring 3 $\frac{1}{2}$ inches by 2 $\frac{1}{2}$ inches by 5/16 inch, site welded into a 30 continuous ring. As best seen from Figure 4, the curb angle is secured with its shorter limb against the outer

surface of the side wall 10 and with its longer limb extending horizontally outwards from the upper edge of the wall, by continuous fillet welds at the top of the side sheeting and at the lower edge of the vertical limb of the curb. The outer end of each flange of the roof panels is cut away so that when the end surface of the flange is against the side wall the top portion of the panel overlaps the curb angle. The outer end of the return flange 16 rests on a bracket formed by a bent plate cleat 18, site welded to the vertical side wall 10, which takes the vertical reaction from the flanged part and distributes it gradually down the shell plating. A bolt 19 passes through registering holes in the return flange 16 and cleat 18.

At the inner end of each flange of the roof panels (see particularly Figure 5) a 3 inch square by $1/4$ inch thick pad plate 20 is welded on to the end surface of the flanged portion, the vertical flange 15 and return flange 16 being cut away so that the outer surface of plate 20 is vertical and flush with the end of the top portion of the panel. The central crown member 11 is in the form of a ring fabricated from steel plates and has an outside diameter of 3 feet, an internal diameter of 1 foot 10 inches and a depth of 4 inches. It is composed of two annular plates 21, 22 connected together by two vertical cylindrical plates 23, 24, the connection between the plates being made by welding. The inner ends of the flanged panels abut against the outer face of the crown ring and, for temporary erection purposes, are attached to it by means of bolts 25, passing through appropriately positioned holes in the pad plates 20 and in the cylindrical plates 23, 24 of the crown ring. The permanent connection between the panels and the crown

ring is obtained by welding the pad plates to the crown ring. A circular top closure plate 26 of about 3 feet 6 inches diameter overlies the crown ring. The marginal portion of this plate, which projects beyond the crown ring, 5 is flanged downwardly and attached to the roof panels by fillet welding along its periphery.

In assembling the roof structure, the curb angles 17 and cleats 18 are welded to the side sheeting and a temporary support is erected to carry the central crown ring. 10 First, the double flanged panel 12 is lifted into position and held by the bolts 19 at its outer end and by the bolts 25 at its inner end. The 28 single flanged panels 13 are then lifted in turn, placed with the unflanged edge on top of the flanged part of the adjacent plate and held in position by 15 their bolts 19 and 25. After all the flanged panels are in position, their unflanged edges are continuous welded to the upper surface of the adjacent underlying panels and, for a distance of some six inches inwardly from the side wall, the flanged edges of the panels are welded to the under 20 surfaces of the adjacent overlying panels. The outer peripheral edges of the panels are continuous welded to the curb angle 17 and the pad plates 20 are welded to the outer face of the crown ring.

The temporary centre support has been retained during 25 all of the preceding assembly and the load on it has been gradually increased. The panels have been acting as simply supported beams with vertical reactions at their outer ends to the cleats and vertical reactions at their inner ends to the central crown ring. When the 30 aforementioned welding has been completed, the temporary support is removed through the still unclosed gap in the

5 roof. Each panel then acts as a half arch with continuity through the crown ring. The curb angle and adjacent portions of the roof sheets and side sheets supply the abutments of the arch and under the dead load of the roof are put into a state of bending and direct tension.

10 To complete the assembly of the roof, the unflanged closure plate 14 is placed in position and continuous fillet welded to the adjacent underlying flanged plates 12 and 13. The circular top closure plate 26 is placed in position and continuous welded at its outer peripheral edge to the underlying panels, a packing plate 27 being inserted above the double flanged panel 12 to make up the difference in level between it and the adjacent panels. The outer peripheral edges of the panels are continuous welded to the 15 curb angle 17.

20 In an alternative construction, which may be employed where additional strength is required, or where corrosive liquids are to be stored, or where other conditions merit it, every second panel is constructed of thicker material and flanged along both radial edges while the intervening panels are left unflanged, all the panels being thus similar to the panels 12 and 14 of Figures 1 to 6. Figure 7 shows a section (corresponding to Figure 6) through a roof for a 35 foot diameter tank constructed in this 25 alternative manner. The roof is composed of only 18 panels, the nine panels 28 being constructed from 1/4 inch plate and formed at both radial edges with downwardly extending flanges 29 and inwardly extending return flanges 30, precisely similar to the flanges 15, 16 already described, 30 while the nine panels 31 are of 3/16 inch plate and are unflanged. A packing plate (similar to plate 27 of Figure 3)

is in this case inserted between each of the panels 28 and the circular closure plate 26 applied over the crown ring. The construction and manner of erection of this roof is in other respects as already described with reference to Figures 1 to 6.

5 In order to reduce the amount of shop workmanship required and to reduce the bulk of the roof for shipping purposes, the flanges and return flanges 15, 16 and 29, 30 may be replaced by plain flanges and Figures 8 and 9 show 10 constructions embodying this modification. In Figure 8, as in Figures 1 to 6, one of the panels 32 is provided with flanges 33 at both radial edges and an adjacent panel 34 is without flanges, all the remaining panels 35 having a flange 33 at one radial edge only. In Figure 9, as in Figure 7, panels 36, 15 provided with flanges 37 at both radial edges, alternate with panels 38 which are unflanged. The flanges 33 and 37 have a depth considerably greater than the depth of the flanges 15 and 29.

For the smaller diameters of roof, such plain flanges 20 alone afford sufficient stiffening to the roof panels, but for larger diameters and pressures additional strength and stiffening may be required. In such cases, as an alternative to the use of return flanges (such as 16, 30), stiffening plates extending transversely to the panels may be secured 25 between the inner surface of the flanges and the undersurface of the top portions of the panels. Figure 8 shows a single substantially triangular stiffening plate 39 of this kind, continuous fillet welded on both sides to the flange 33 of one of the panels 35 and to the top portion of that panel. 30 In practice a number of such plates would be provided at suitable intervals along the length of all or some of the

flanged panels. Figure 9 shows a single substantially rectangular stiffening plate 40 secured at its ends by continuous fillet welds on both sides to both flanges of one of the panels 36 and at its upper edge by intermittent fillet welds on both sides to the top part of that panel. Again a number of such plates would in practice be provided at intervals along the length of all or some of the flanged panels. In the construction of Figure 9, triangular stiffening plates, such as 39, could be used either in 10 place of or in addition to the plates 40.

It will be understood that the constructions described are intended by way of example only and that the invention is not limited to the dimensions given nor to the details of construction described, many modifications 15 besides those specifically mentioned being possible within the scope of the appended claims. Thus, for example, the roof may be constructed wholly or partly of aluminium alloy, or other suitable metal, instead of steel.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A conical roof for a circular structure such as a liquid storage tank, which comprises a peripheral curb of angle section having a vertical limb secured to the upper edge of said wall and a horizontal limb projecting outwardly therefrom, a plurality of radially disposed sheet metal panels together constituting the conical roof surface, the outer ends of said panels extending outwardly over the upper edge of said wall and being secured to said curb, a downwardly extending stiffening flange formed integrally upon the radial edge of one of said panels at each of the junctions between pairs of adjacent panels to convert said panel into a girder, the edge of the second panel of said pair being unflanged and projecting over the flanged edge of said first panel, said stiffening flange extending to the inner end of said panel but terminating inwardly of said tank wall, a bracket projecting inwardly from said wall and supporting each of said stiffening flanges, an annular crown member having a depth substantially equal to that of said flanges to which all the panels are secured at their inner ends with their surfaces substantially level with the upper surface of said crown member, said crown member being supported solely by said panels, said crown comprising two spaced-apart concentric cylindrical members and flat rings joining said members at their upper and lower edges respectively, said members and rings being welded to form a unitary structure, and a circular closure plate covering said crown member and extending outwardly over and secured to each of said panels, the panels being unsupported otherwise than at their ends so that they act as half arches with continuity through said crown member.
2. A roof in accordance with claim 1, comprising at least one pair of adjacent panels one of which is flanged at both its radial edges while the other is not flanged at either radial edge, all the remaining panels being flanged at one radial edge only.

3. A roof in accordance with claim 1, in which every second panel is flanged at both its radial edges and the remaining panels are unflanged at their edges.

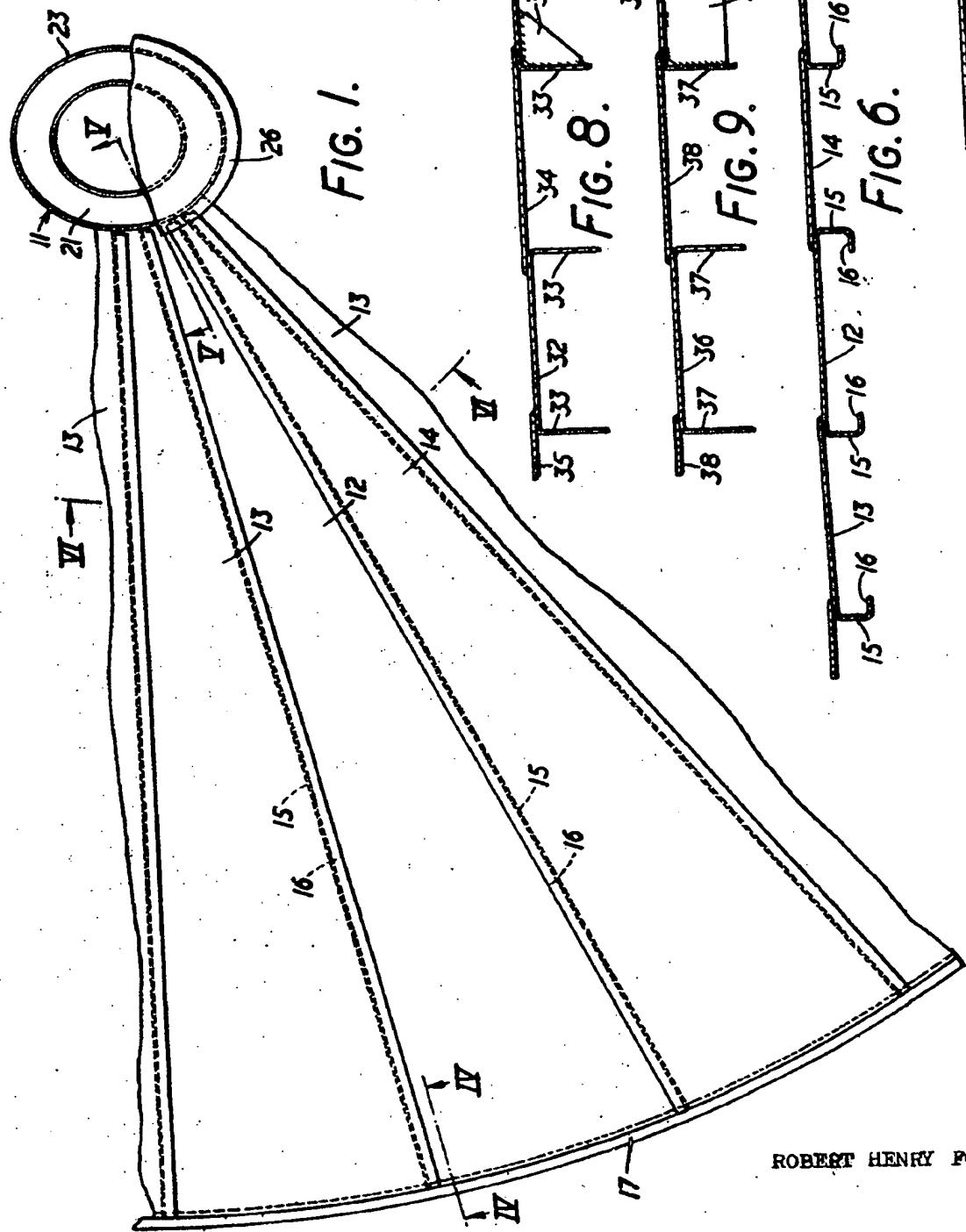
4. A roof in accordance with claim 1, or 2, or 3, in which some at least of the flanges on the radial edges of the panels comprise a downwardly extending portion and a return flange portion extending inwardly beneath the top portion of the panel from the lower end of the downwardly extending portion.

5. A roof in accordance with claim 1, or 2, or 3, in which some at least of the flanges on the radial edges of the panels are plain flanges, comprising only a downwardly extending portion.

6. A roof in accordance with claim 1, or 2, or 3, in which some at least of the flanges on the radial edges of the panels are plain flanges, comprising only a downwardly extending portion, and in which at least some of the panels are provided with at least one stiffening plate, extending transversely to the panel and secured to the inner surface of a flange of the panel and to the undersurface of the top portion of the panel.

7. A roof in accordance with claim 1, or 2, or 3, in which some at least of the flanges on the radial edges of the panels are plain flanges, comprising only a downwardly extending portion, and in which at least some of the stiffening plates are of substantially triangular form and are secured along two adjacent edges to the flange and the top portion of the panel respectively.

8. A roof in accordance with claim 1, or 2, or 3, in which some at least of the flanges on the radial edges of the panels are plain flanges, comprising only a downwardly extending portion, and in which at least some of the stiffening plates are of substantially rectangular form and are secured along two opposite edges to flanges formed on opposite radial edges of a panel and along a third edge to the top portion of that panel.

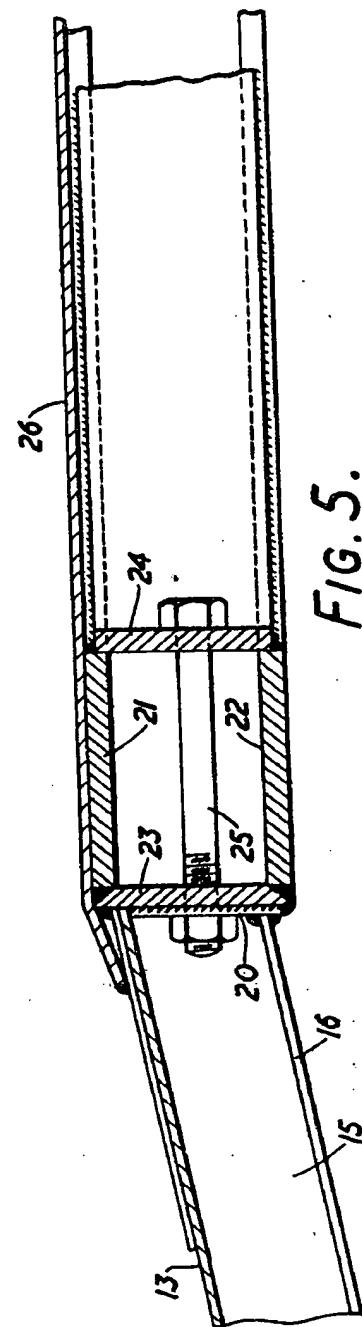
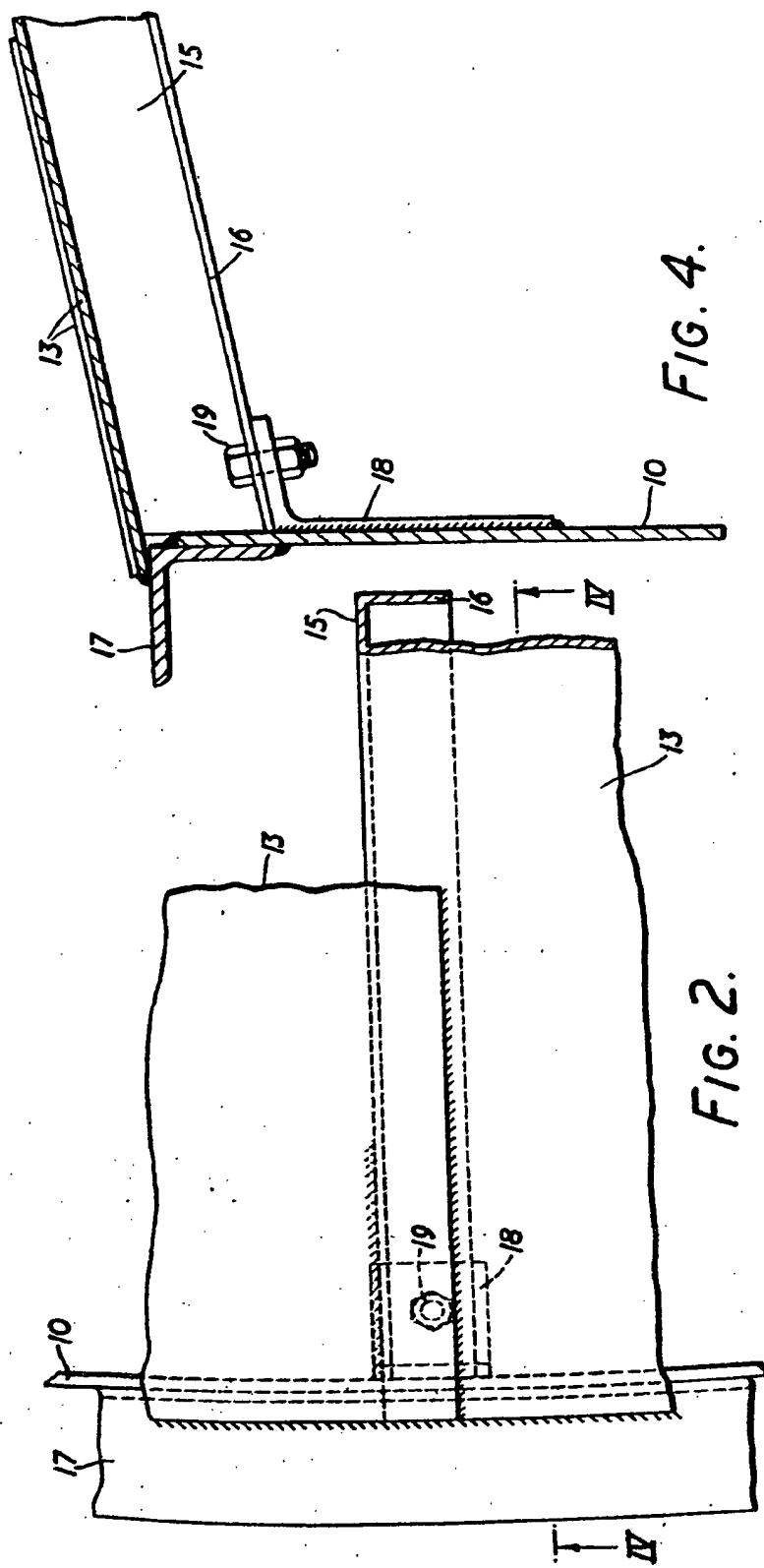


INVENTOR

ROBERT HENRY FOSTER & JAMES McLEA

PATENT AGENT

Seelerstonhough



INVENTOR

ROBERT HENRY FOSTER &
JAMES McLEAN

PATENT AGENTS

Foster and Daugler & Co.

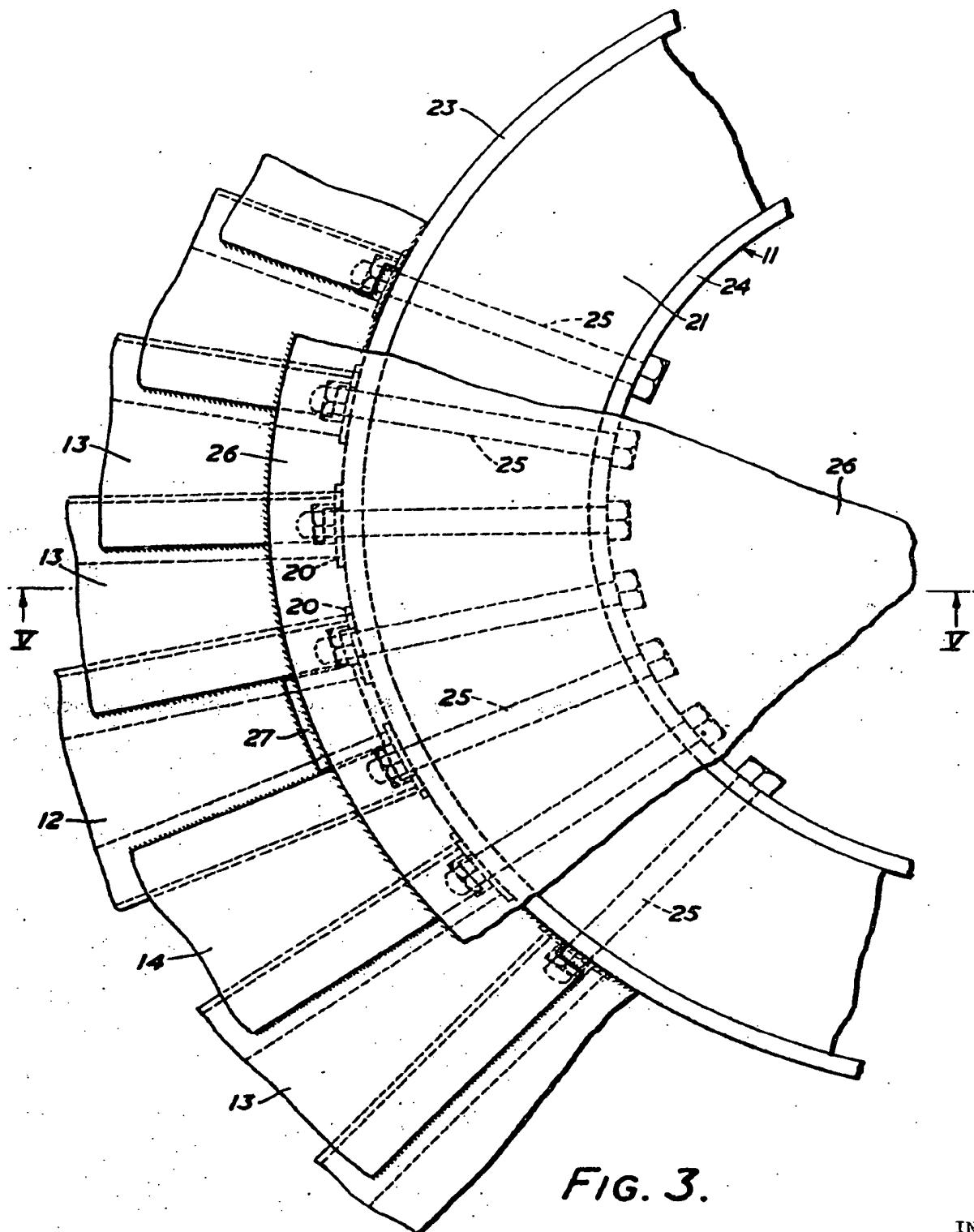


FIG. 3.

INVENTOR

ROBERT HENRY FOSTER &
JAMES McLEAN

PATENT AGENTS

Foster,tonshay & Co